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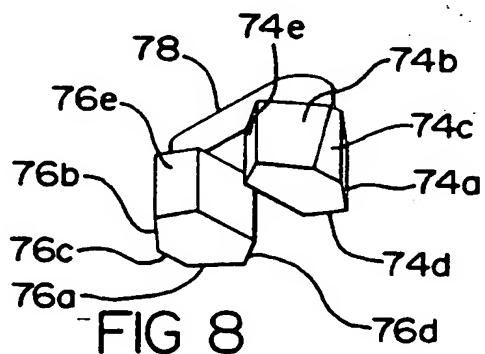
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### (54) Synchronizer with self-energizing.

(57) A baulkring-type synchronizer (18) includes cone clutch friction surfaces (24,48 and 26,50) and jaw clutch teeth (36b,28 and 36c,30) for frictionally synchronizing and positive connecting gears (14,16) to a shaft (12). A plurality of rigid members (72) are drivingly interposed between blocker teeth (44,46) affixed to baulkings (40,42) and self-energizing ramp surfaces (70a-70d) defined on an outer circumference of a hub 32 affixed to the shaft (12). A shift sleeve (34) is slidably splined to the hub (32) and is moved by an operator shift force ( $F_o$ ) and an additive force ( $F_a$ ) provided by the self-energizing ramp surfaces. Both forces ( $F_o$  and  $F_a$ ) react against the blocker teeth to engage the friction surfaces. The self-energizing ramp surfaces may be long enough to assist shift completion as unblocking occurs. The rigid members (72) are mounted with limited relative rotation on the shift sleeve (34) e.g. in circumferential slots (34a).



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## Field of the Invention

This invention relates to a baulkring-type synchronizer having self-energizing.

## Background of the Invention

Baulkring-type synchronizer mechanisms for use in multi-ratio transmissions are well known. Such mechanisms include pairs of friction and jaw members for respectively synchronizing and positive clutching a gear to a shaft, pre-energizer assemblies for engaging the friction members in response to initial engaging movement of a shift sleeve, a hub rotatably fixed to the shaft and having external spline teeth slidably receiving internal spline teeth of the shift sleeve which often defines one of the jaw member pairs, a baulkring having blocker teeth for arresting engaging movement of the shift sleeve until synchronization is reached and for transferring a shift force from the sleeve to increase the engaging force of the friction members.

It is also known in the multiple ratio transmission art that synchronizer mechanisms may be used to reduce shift time of all or some of the transmission gear ratios. It is also known that the shift effort required by a vehicle operator, i.e., force applied to a shift lever, may be reduced by use of synchronizer mechanisms of the self-energizing type. Since operator shift effort generally increases with vehicle size and weight, synchronizer mechanisms of the self-energizing type are especially important for trucks, particularly for heavy duty trucks. A baulkring-type synchronizer of the self-energizing type may be seen by reference to U.S. Patent 3,548,983, which is incorporated herein by reference. A pin-type synchronizer of the self-energizing type may also be seen by reference to U.S. Patent 5,092,439, which is also incorporated herein by reference.

## Summary of the Invention

An object of this invention is to provide a baulkring-type synchronizer with improved self-energizing.

According to a feature of the invention, a clutch frictionally synchronizes and positively connects first and second drives disposed for relative rotation about a common axis. The clutch comprises first jaw means axially movable from a neutral position to an engaged position with second jaw means for positive connecting the drives in response to engaging movement of the first jaw means by an axially directed shift force  $F_o$ . The first jaw means includes a central opening having internal splines with axially extending flank surfaces slidably mating continuously with axially extending flank surfaces of external splines for preventing relative rotation between the internal and external splines. The external splines are affixed against rota-

tion and axial movement relative to the first drive. A first friction surface is axially movable into engagement with a second friction surface in response to the engaging movement of the first jaw means for producing a synchronizing torque. First and second blocker means have angled surfaces movable into engagement in response to the engaging movement of the first jaw means for preventing asynchronous engagement of the jaw means, for transmitting the shift force ( $F_o$ ) to the first friction surface to effect an engagement force of the friction surfaces, and for producing a torque counter to the synchronizing torque for moving the first and second blocker means out of engagement as synchronization is reached. First and second self-energizing means are operative when engaged to react the synchronizing torque for producing an additive axial force ( $F_a$ ) in the direction of the shift force ( $F_o$ ) for increasing the engagement force of the friction surfaces. The first and second self-energizing means include means for directing the additive axial force ( $F_a$ ) to the first friction surface via the blocker means.

The clutch is characterized by a hub including an outer circumference defining the external splines. A baulkring includes the first friction surface and a plurality of second blocker surfaces defining the second blocker means. The baulkring is axially movable away from the hub toward the second friction surface. The first jaw means central opening and internal splines are defined by a shift sleeve. The first self-energizing means include a plurality of first self-energizing ramp surfaces defined in the hub outer circumference. A plurality of rigid members are mounted on the shift sleeve for limited rotation relative thereto and substantially affixed against axial movement relative thereto. Each rigid member includes one side defining a second angled self-energizing surface of the second self-energizing means and another side defining a blocker surface of the first blocker means. Each rigid member is interposed one of the second blocker surfaces and one of the first self-energizing surfaces such that both the axially directed shift force ( $F_o$ ) and the additive axial force ( $F_a$ ) are transferred across the rigid member.

## Brief Description of the Drawings

The synchronizer of the invention is shown in the accompanying drawings in which:

- 50 Figure 1 is a sectional view of a double-acting baulkring-type synchronizer in a neutral position and disposed for rotation about the axis of a shaft;
- 55 Figures 2 and 3 are relief views of broken away portions of components in Figure 1 looking axially relative to the shaft;
- Figure 4 is a relief view of components of the synchronizer in Figure 1 with the components rotated

90 degrees relative to Figure 1 and 60 degrees relative to Figures 5-7, and with a shift sleeve in Figures 1 and 6 removed; Figure 5 is a relief view of a baulk ring in Figures 1, 4 and 7; Figure 6 is a relief view of a shift sleeve of the synchronizer in Figure 1; Figure 7 is the assembled components of Figure 4 rotated 60 degrees relative to Figure 4 plus the rigid member of Figure 8; Figure 8 is a perspective view of a rigid member in Figures 1 and 7; Figures 9A-9H schematically illustrate an alternative embodiment of blocking and self-energizing components in Figures 1-8 and several stages of operation of the components which also apply to the embodiment of Figures 1-8; Figure 10 is a graphical representation of axial forces and torques acting across blocker surfaces of the synchronizer mechanism; and Figures 11, 12, 13A and 13B illustrate three modified embodiments of portions of the synchronizer in Figures 9A-9H.

#### Detailed Description of the Drawings

The term "synchronizer clutch mechanism" shall designate a clutch mechanism utilized to non-rotatably couple a selected ratio gear to a shaft by means of a positive clutch in which attempted engagement of the positive clutch is prevented until members of the positive clutch are brought to substantially synchronous rotation by a synchronizing friction clutch associated with the positive clutch. The term "self-energizing" shall designate a synchronizer clutch mechanism which includes ramps or cams or the like to increase the engaging force of the synchronizing clutch in proportion to the synchronizing torque of the friction clutch.

Looking now at Figures 1-8, therein is shown a gear and synchronizer assembly 10 which forms part of a multi-ratio change speed transmission. Assembly 10 includes a shaft 12 mounted for rotation about a central axis 12a, axially spaced apart gears 14,16 supported on the shaft for rotation relative thereto and secured against axial movement relative to the shaft in known manner, and a double-acting synchronizer clutch mechanism 18.

The synchronizer clutch mechanism 18 includes annular members 20,22 axially and rotatably affixed to gears 14,16 in known manner, gear friction surfaces 24,26 herein integral with members 20,22, gear jaw teeth 28,30 herein integral with members 20,22, a hub member 32 axially and rotatably affixed at a central opening 32a thereof to shaft 12, a shift sleeve 34, internal spline teeth 36 defined on a central opening of sleeve 34 and in constant mesh with external spline teeth 38 defined on the outer circumference of

hub 32, baulk rings 40,42, blocker teeth sets 44,46 and friction surfaces 48,50 herein integral with baulk rings 40,42, pre-energizer assemblies 52, and a self-energizing/blocker assembly 54. Herein, the synchronizer includes three circumferentially spaced apart self-energizing/blocker assemblies 54 which cooperate with a like number of blocker teeth on each baulk ring, and three circumferentially spaced apart pre-energizer assemblies. Each blocker tooth 44,46 respectively includes angled blocker surfaces 44a,44b,46a,46b. As is readily seen, friction surfaces 24,48 and 26,50 pair up to define friction clutches for synchronizing the gears to the shaft prior to engagement of the jaw clutch members. Cone clutches are preferred; however, other types of friction clutches may be used. A wide range of cone angles may be used. Cone angles of seven and one-half degrees are employed herein. The friction surfaces may be defined by any of several known friction materials affixed to the base member, e.g., pyrolytic carbon friction materials such as disclosed in U.S. Patents 4,700,823; 4,844,218 and 4,778,548 may be used. These patents are incorporated herein by reference.

Spline teeth 36,38 have axially extending flank surfaces 36a,38a which continuously mate in close sliding relation so that there is relatively no free play between shift sleeve 34 and shaft 12. Opposite ends of splines 36 define jaw teeth 36b,36c which respectively mate with gear teeth 28,30 to positive clutch the gears to the shaft. With reference to Figures 9, the flank side of jaw teeth 36b,36c and of gear jaw teeth 28,30 are provided with an antibackout or locking angle feature to prevent inadvertent disengagement of the teeth. Details of this feature may be seen by reference to U.S. Patent 4,727,968 which is incorporated herein by reference. As may be seen in Figure 9H, when jaw teeth 36c and 30 are fully engaged there remains a substantial engaged length of flank surfaces 36a,38a to distribute forces from transmitted torque and thereby minimize wear.

Each pre-energizer assembly 52, which is known in the art, includes a helical compression spring 58 and plunger 60 disposed in a radially extending blind bore in hub 32 and biasing a roller or ball 62 (herein a roller) into an annular detent groove 36d in shift sleeve splines 36. Pre-energizer assembly 52 resiliently positions shift sleeve 34 in the neutral position shown in Figures 1 and 9A. Rollers 62 are axially spaced between abutment surfaces 64a,66a of a plurality of tabs 64,66 (herein three) formed integral with baulk rings 40,42. The tabs extend into recesses 36b in hub 32 for limiting rotation of the baulk ring relative to the hub and shaft.

When it is desired to couple either gear to the shaft, an appropriate and unshown shift mechanism, such as disclosed in U.S. Patent 4,920,815 and incorporated herein by reference, moves shift sleeve 34

axially via a partially shown shift fork 68 along the axis of shaft 12 either left to couple gear 14 or right to couple gear 16. The shift mechanism may be manually moved by an operator through a linkage system, may be selectively moved by an actuator, or may be moved by means which automatically initiate shift mechanism movement and which also controls the magnitude of the force applied by the shift mechanism. When the shift mechanism is manually moved, pre-energizer assemblies apply a pre-energizer force proportional to the force applied by the operator to the shift sleeve. Whether manually or automatically applied, the force is applied to the shift sleeve in an axial direction and is proportional to the force  $F_o$  in Figure 10. The pre-energizer force, depending on direction of shift sleeve movement by the shift force ( $F_o$ ), moves either friction surface 48 or 50 into initial engagement with its associated friction surface to clock the associated baulkring to a position relative to hub 32 for positioning the self-energizing/blocker assemblies 54 in a manner explained hereinafter.

Self-energizing/blocker assemblies 54 each comprise self-energizing means 70 including self-energizing or boost ramp surfaces 70a, 70b, 70c, 70d extending oblique to the rotational plane of hub 32 and defined in the outer circumference of the hub and non-boost surfaces 70e, 70f extending perpendicular to the rotational plane, the blocker teeth 44, 46, and a rigid member 72 for reacting blocker and self-energizing forces. Member 72 includes circumferentially spaced apart end portions 74, 76 rigidly secured together by a circumferentially extending portion 78 received in a circumferentially extending slot 34a in shift sleeve 34. Slot 34a allows limited circumferential movement of member 72 therein relative to the sleeve and prevents axial movement therein relative to the sleeve. End portion 74 includes self-energizing ramp surfaces 74a, 74b which respectively react against surfaces 70b, 70a when shift sleeve 34 is moved axially left or right, a non-boost surface 74c which reacts against surface 70e when the synchronizer clutch mechanism 18 is in the neutral position of Figures 1 and 7, and blocker surfaces 74d, 74e which respectively react against surfaces 44a, 46a of blocker teeth 44, 46. In a like manner, end portion 76 includes self-energizing ramp surfaces 76a, 76b for respectively reacting against surfaces 70d, 70c, a non-boost surface 76c for reacting against surface 70f, and blocker surfaces 76d, 76e for respectively reacting surfaces 44b, 46b. The engaged position of non-boost surfaces 70e, 70f, 74c, 76c prevents unwanted activation of the self-energizing ramps in the event there is some amount of torque produced by one of the cone clutches, e.g., viscous shear of oil between the cone clutch friction surface may produce a torque that could otherwise activate the ramps.

Looking now at the self-energizing/blocker assembly 80 in Figures 9A-9H, this schematically illu-

strated embodiment differs from the previous embodiment in that blocker teeth 44, 46 include axial extensions 44c, 46c received between rigid member ends 74, 76 which are circumferentially spaced further apart, as are the self-energizing ramp surfaces defined by hub 32. Extensions 44c, 46c are to ensure positioning of teeth 44, 46 between ends 74, 76.

Function of both self-energizing/blocker assemblies is described relative to Figures 9A-9H. The description assumes an asynchronous condition exists between shaft 12 and gear 16 in a direction that engages the surfaces illustrated. Asynchronous conditions in the other direction or for gear 14 produce surface engagements that should be obvious from the following description. Figure 9A illustrates a "neutral position" of all synchronizer components. However, at the start of a shift extensions 44c, 46c may be circumferentially positioned any place between ends 74, 76. Initial rightward axial movement of shift sleeve 34 by the operator shift force  $F_o$  is transmitted by pre-energizer rollers 62 to baulkring 42 via tab abutment surfaces 66a to effect initial frictional engagement of movable cone surface 50 with gear cone surface 26. The initial engagement force of the cone surface is, of course, a function of the force of spring 58 and the angles of the walls of detent grooves 36d. Figure 9B illustrates initial movement of rigid members 72 from the neutral position in response to axial movement of shift sleeve 34 toward jaw teeth 30 affixed to gear 16. The components in Figure 9B may be considered to be in a "pre-pre-energized position" wherein the pre-energizer assemblies have not moved baulkring 42 enough to engage cone clutch friction surfaces 26, 50. The components in Figure 9C are in a "pre-energized position" wherein the friction surfaces are engaged enough to start transmitting torque and start to rotate baulkring 42 relative to the hub and shift sleeve enough to engage blocker surfaces 74e, 46a but not enough to move rigid member 72 from its circumferential mid position in shift sleeve slot 34a. See Figure 6. In the "blocking/self-energizing position" of Figure 9D, the torque has rotated baulkring 42 and rigid members 72 enough to also engage self-energizing surfaces 70b, 74a. Hence, in Figure 9D surfaces 74e, 74a are trapped between baulkring blocker surfaces 46a and hub self-energizing ramp surfaces 70b. When these surfaces are so trapped and ignoring the effect of the self-energizing ramp surfaces, full operator shift force ( $F_o$ ) applied to rigid member 72 from shift sleeve 34 is transmitted across blocker surfaces 74e, 46a, thereby engaging friction surfaces 26, 50 with force  $F_o$  for producing a synchronizing torque  $T_o$ . If self-energizing ramp surfaces 70b, 74a were normal to the plane of rotation of hub 32, no self-energizing forces would be produced and only torque  $T_o$  would be reacted to shaft 12. Also, since blocker surfaces 74e, 46a are oblique to the plane of rotation, they in addition to preventing asynchronous engage-

ment of jaw teeth 36a,30 and transmitting the shift force  $F_o$  to friction surfaces 26,50, also produce a counter torque or unblocking torque counter to the synchronizing torque but of lesser magnitude during asynchronous conditions. As substantial synchronism is reached, the synchronizing torque drops below the unblocking torque, whereby the blocker teeth move out of engagement to allow continued axial movement of the shift sleeve and engagement of movable jaw teeth 36c with gear jaw teeth 30.

Still ignoring the effects of the self-energizing ramps, cone clutch torque provided by the force  $F_o$  is expressed by the following equation:

$$T_o = F_o R_c \mu_c / \sin \alpha$$

where:

$R_c$  = the mean radius of the cone friction surface,  
 $\mu_c$  = the coefficient of friction of the cone friction surface, and  
 $\alpha$  = the angle of the cone friction surfaces.

Looking now at the affects of the self-energizing ramp surfaces, the synchronizing torque  $T_o$  due to the operator applied axial shift force  $F_o$  is, of course, reacted across the ramp surfaces, which surfaces produce an axial force component or axial additive force  $F_a$  acting in the same direction as operator shift force  $F_o$  and also transmitted across the blocker surfaces, thereby further increasing the engaging force of the friction surfaces to provide an additive synchronizing torque which adds to the torque  $T_o$ . Figure 10 graphically illustrates the sum of the axial forces  $F_o$  plus  $F_a$  engaging the clutch friction surfaces and the sum of the synchronizing torques  $T_o$  plus  $T_a$  produced by the clutch friction surfaces. For a given operator shift force  $F_o$  and an operator synchronizing torque  $T_o$ , the magnitude of the axial additive force is preferably a function of the angle of the engaged self-energizing ramp surfaces. This angle is preferably great enough to produce an additive force  $F_a$  of magnitude sufficient to increase synchronizing torque and decrease synchronizing time in response to a given moderate shift effort by the operator. However, this angle is also preferably low enough to produce a controlled axial additive force  $F_a$ , i.e., the force  $F_a$  should increase or decrease in response to the force  $F_o$  increasing or decreasing. If the ramp angle is too great, the ramps are self-locking rather than self-energizing; hence, once initial engagement of the cone clutch is effected, the force  $F_a$  will rapidly and uncontrollably increase independent of the force  $F_o$ , thereby driving the cone clutch toward lockup. Self-locking rather than self-energizing decreases shift quality or shift feel, may over stress synchronizer components, may cause over heating and rapid wear of the cone clutch surfaces, and may even override operator movement of the shift lever.

If no additive axial force is preferred for an up or downshift of a gear, the ramp surfaces for the up or downshift may be made parallel to the splines. For ex-

ample, if ramp surface 70b,74a are made parallel to splines 38, no additive force  $F_a$  is provided (for a shift in that direction).

The main variables for calculating self-energizing

ramp angles  $\theta$  and for providing additive axial forces  $F_a$ , which increase or decrease in proportion to operator forces  $F_o$ , are cone clutch angle  $a$ , cone clutch coefficient of friction  $\mu_c$ , mean radii ratio  $R_c$  of the cone clutch and  $R_r$  of the self-energizing ramps, ramp coefficient of friction  $\mu_r$ , and angle of the self-energizing ramps. Further details for calculating and controlling self-energizing or boost forces may be obtained by reference to U.S. Patent 5,092,439 which is incorporated herein by reference.

Figure 9E illustrates a "boosted/unblocked position" which occurs immediately after unblocking torque has separated the blocking surfaces. Self-energizing which occurs in this position may be due to inertia of baulkring 42 and/or while there is less than complete disengagement of the cone clutch. This self-energizing phenomenon continues during the "boosted into gear position" of Figure 9F and provides an axial assist force acting on shift sleeve 34 in the direction of shift force  $F_o$ . The assist force helps to restart axial engaging movement of jaw teeth 36c toward engagement with jaw teeth 30 as unblocking occurs and helps move the jaw teeth into engagement when the V-shaped ends of teeth 36a and 30 engage. The assist force lessens what is known as shift notchiness by decreasing the need for the operator to move the shift lever with extra effort to finish a shift as unblocking occurs, i.e., the assist force facilitates smooth and relatively effortless completion of shifts. Figure 9G illustrates an "end of boost position" and Figure 9H illustrates a full "engaged position" of jaw teeth 36c,30.

Extensions 44c, 46c are axially long enough to remain trapped between rigid member ends 74, 76 when the synchronizer components are in the neutral position of Fig. 9A and while the blocker surfaces of blocker teeth 44, 46 are engaged with the blocker surfaces of rigid member ends 74, 76, as illustrated in Figures 9B-9E. However, as may be seen by reference to Figures 9F-9H, when unblocking occurs for the illustrated shift, extension 46c becomes untrapped or not physically maintained in alignment with the circumferential space between the ends of each rigid member, thereby allowing or not preventing random movement of extension 46c to a position between end 76 and self-energizing means 70. When this occurs the synchronizer components can not be returned to neutral and a shift into gear 14 can not be made.

Figures 11,12,13A and 13B schematically illustrate three modified embodiments which each retain circumferential positioning of the extensions between ends 74, 76 of the rigid member 72, thereby maintaining alignment with the circumferential space between the rigid member ends and insuring engagement of

the blocker surfaces when a shift change is initiated. In Fig. 11 the modified extensions are designated 144c, 146c, therein at least one pair of extensions 144c; 146c, includes actually extending bores 144d, 146d which slidably receive a pin 90 for preventing relative circumferential movement of the extensions and for allowing relative axial movement of the extensions. In Fig. 12 the modified extensions are designated 244c, 246c, therein at least one extension 244c slidably extends into circumferentially spaced apart portions of extension 246c. In Fig's. 13A and 13B the modified extensions are respectively designated 344c, 346c and 444c, 446c. In Fig. 13A at least one pair of the extensions 344c, 346c axially overlap to prevent relative circumferential movement in one direction. In Fig. 13B at least one other pair of the extensions 444c, 446c are reversed to prevent relative circumferential movement in the other direction.

Several embodiments of a synchronizer mechanism with self-energizing has been disclosed. Many variations and modifications of the embodiments are believed to be within the spirit of the invention. The following claims are intended to cover the inventive portions of disclosed mechanism and variations and modifications believed to be within the spirit of the invention.

## Claims

1. A clutch (18) for frictionally synchronizing and positive connecting first and second drives (12,16) disposed for relative rotation about a common axis (12a); the clutch comprising:

first jaw means (36c) axially movable from a neutral position to an engaged position with second jaw means (30) for positive connecting the drives in response to engaging movement of the first jaw means (36c) by an axially directed shift force ( $F_o$ ), the first jaw means (36c) including a central opening having internal splines (36) with axially extending flank surfaces (36a) slidably mating continuously with axially extending flank surfaces (38a) of external splines (38) for preventing relative rotation between the internal and external splines, and the external splines (38) affixed against rotation and axial movement relative to the first drive (12);

a first friction surface (50) axially movable into engagement with a second friction surface (26) in response to the engaging movement of the first jaw means (36c) for producing a synchronizing torque ( $T_o$ );

first and second angled blocker surfaces (74e,46a) movable into engagement in response to the engaging movement of the first jaw means (36c) for preventing asynchronous engagement of the jaw means (36c,30), for transmitting the

shift force ( $F_o$ ) to the first friction surface (50) to effect an engagement force of the friction surfaces (50,26), and for producing a torque counter to the synchronizing torque for moving the first and second blocker means (74,46) out of engagement as synchronization is reached;

5 first and second self-energizing means (70,74) operative when engaged to react the synchronizing torque for producing an additive axial force ( $F_a$ ) in the direction of the shift force ( $F_o$ ) for increasing the engagement force of the friction surfaces (50,26), the first and second self-energizing means (70,74) including means (74) for directing the additive axial force ( $F_a$ ) to the first friction surface (50) via the blocker surfaces (74e,46a); characterized by:

10 a hub (32) including an outer circumference defining the external splines (38);

15 a first baulk ring (42) including the first friction surface (50) and a plurality of the second blocker surfaces (46a), the baulk ring being axially movable away from the hub (32) toward the second friction surface (26);

20 the first jaw means (36c) central opening and internal splines (36) defined by a shift sleeve (34);

25 the first self-energizing means (70) including a plurality of first self-energizing ramp surfaces (70b) defined in the hub (32) outer circumference;

30 a plurality of rigid members (72) mounted on the shift sleeve (34) for limited rotation relative thereto and for non-axial movement relative thereto, each rigid member (72) including one side (74a) defining a second angled self-energizing ramp surface (74a) of the second self-energizing means (74) and another side (74e) defining the first blocker surface (74e), each rigid member (72) interposed one of the second blocker surfaces (46a) and one of the first self-energizing ramp surfaces (70b) such that both the axially directed shift force ( $F_o$ ) and the additive axial force ( $F_a$ ) are transferred across the rigid member (72).

35 40 45 50 55 2. The clutch of claim 1, wherein the hub (32) and at least one of the rigid members (72) each include a non-boost surface (70e,74c) extending perpendicular to a rotational plane of the hub and engaged when the shift sleeve (34) is in a neutral position.

3. The clutch of claim 1, wherein the self-energizing ramp surfaces (70b,74a) remain engaged after the first and second blocker surfaces (74e,46a) move out of engagement for providing an assist force for moving the first jaw means (36c) into engagement with the second jaw means (30).

4. The clutch of claim 3, wherein the hub (32) and at least one of the rigid members (72) each include a non-boost surface (70e,74c) extending perpendicular to a rotational plane of the hub and engaged when the shift sleeve (34) is in a neutral position.

5. The clutch of claim 1, further including a third drive (14) disposed for rotation about the common axis (12a) relative to the first and second drives (12,16) and axially spaced from the second drive (16);

the shift sleeve (34) internal splines (36) defining a third jaw means (36b) axially movable from a neutral position into an engaged position with a fourth jaw means (28) for positive connecting the first and third drives (12,14) in response to engaging movement of the shift sleeve (34) by a second shift force ( $F_o$ ) directed axially opposite the first shift force ( $F_a$ );

a second baulkring (40) including a third friction surface (48) and a plurality of fourth blocker surfaces (44a), the baulkring being axially movable away from the hub (32) toward a fourth friction surface (24);

the first self-energizing means (70) including a plurality of third self-energizing ramp surfaces (70a) defined in the hub (32) outer circumference;

the rigid members (72) each including a side (74b) defining a fourth angled self-energizing ramp surface (74b) of a second self-energizing means (74) and another side (74d) defining a third blocker surface (74d), each rigid member (72) interposed one of the fourth blocker surfaces (44a) and one of the third self-energizing surfaces (70a) such that both the axially directed shift force ( $F_o$ ) and the additive axial force ( $F_a$ ) are transferred across the rigid member (72) to the second baulkring (40).

6. The clutch of claim 5, wherein each rigid member includes a first end (74) defining the second and fourth self-energizing ramp surfaces (74a,74b) and defining the first and third blocker surfaces (74e,74d), the surfaces of the rigid member first end (74) for reacting with the first and second self-energizing ramp surfaces (70b,70a) and second and fourth blocker surfaces (44a,46a) to effect synchronizing of the second and third drives with the first drive when the first drive is initially rotating faster than the second and third drives.

7. The clutch of claim 6, wherein each rigid member includes a second end (76) circumferentially spaced from the first end (74) and rigidly secured together by a circumferentially extending portion (78) slidably received in a slot (34a) in the shift

sleeve (34) for allowing the limited relative rotation and the non-axial movement relative to the shift sleeve (34), the second end including self-energizing ramp surfaces (76a,76b) and blocker surfaces (76e,76d) respectively for reacting against additional self-energizing ramp surfaces (70d,70c) defined by the hub and blocker surfaces (46b,44b) defined by the first and second baulkring (42,40), the surfaces defined by the second end and the additional surfaces (70d,70c) to effect synchronizing of the second and third drives with the first drive when the first drive is initially rotating slower than the second and third drives.

8. The clutch of claim 7, wherein the first and second ends (74,76) of at least one of the rigid members (72) each include a non-boost surface (74c,76c) extending perpendicular to a rotational plane of the hub (32) and the hub includes non-boost surfaces (70e,70f) extending perpendicular to the rotational plane and engaging the rigid member non-boost surfaces when the shift sleeve (34) is in a neutral position.

9. The clutch of claim 7, wherein the self-energizing ramp surfaces remain engaged after their associated blocker surfaces move out of engagement for providing an assist force for moving the associated jaw means of the shift sleeve (34) into engagement with the associated jaw means of the second and third drives.

10. The clutch of claim 9, wherein the first and second ends (74,76) of at least one of the rigid members (72) each include a non-boost surface (74c,76c) extending perpendicular to a rotational plane of the hub (32) and the hub includes non-boost surfaces (70e,70f) extending perpendicular to the rotational plane and engaging the rigid member non-boost surfaces when the shift sleeve (34) is in a neutral position.

11. The clutch of Claim 7, including means (90) for maintaining the first and second baulkring blocker surfaces (44a, 44b and 46a, 46b) in alignment with the circumferential space between the ends (74, 76) of each rigid member(72).

12. A clutch (18) for selectively synchronizing and positive connecting a central means (12) with either of axially spaced apart first and second drives (14, 16) disposed for relative rotation about an axis (12a) of the central means (12) and axially fixed relative thereto; the clutch comprising:

a hub (32) affixed to the central means (12) concentric to the axis (12a) and between the drives (14, 16), an outer circumference of the hub

having external splines (38);  
jaw teeth (28, 30) affixed to each drive (14, 16);

a friction surface (24, 26) affixed to each drive (14, 16);

a shift sleeve (34) having internal splines (36) mating with the hub external splines (38) and having jaw teeth (36b, 36c) engagable with the jaw teeth (28, 30) of either of the drives (14, 16) in response to to-or-fro axial engaging movement of the sleeve (34) from a neutral position by an operator shift force  $F_o$ :

a baulkring (40, 42) associated with each drive, each baulkring disposed between the hub (32) and the associated drive (14, 16), each baulkring including a plurality of pairs of blocker surfaces (44a, 44b and 46a, 46b) and a friction surface (48, 50) engagable with the friction surface (24, 26) of the associated drive (14, 16) to produce a synchronizing torque;

blocker surfaces (74d, 74e and 76d, 76e) axially affixed to the sleeve (34) and engagable with the blocker surfaces (44a, 44b and 46a, 46b) of either baulkring (40, 42) in response respectively to the to-or-fro movement of the sleeve (34) for preventing asynchronous engagement of the engagable jaw teeth (36b, 36c), for transmitting the operator shift force ( $F_o$ ) across the engaged blocker surfaces to effect engagement of the associated friction surfaces, and for producing a torque counter to the synchronizing torque;

self-energizing means (70, 74) operative when engaged to react the synchronizing torque for producing an additive axial force ( $F_a$ ) directed across the engaged blocker surfaces and in the direction of the shift force ( $F_o$ ) for increasing the engagement force of the engaged friction surfaces; characterized by:

the self-energizing means (70, 74) including a plurality of circumferentially spaced apart recesses in the hub outer circumference and a rigid member (72) disposed in each recess, each recess having circumferentially spaced apart ends (70e, 70f) defining the circumferential extent thereof, at least one of the ends including first and second self-energizing ramp surfaces (70a, 70b) respectively facing axially on an angle in the direction of first and second drives (14, 16), each rigid member (72) including first and second circumferentially spaced apart ends (74, 76) rigidly secured together by a circumferentially extending portion (78) slidably received in a slot (34a) in the sleeve (34) for allowing limited rotation and non-axial movement relative to the sleeve, each first end (74) including third and fourth self-energizing ramp surfaces (74b, 74a) respectively engagable with the first and second ramp surfaces (70a,

70b) and each end (74, 76) including the blocker surfaces z974d, 74e and 76d, 76e) axially affixed to the shift sleeve (34), and during synchronization each first end (74) positioned between one of the recess self-energizing ramp surfaces (70a, 70b) and one of the baulkring blocker surfaces (44a, 46a) such that both the axially directed shift force and the additive axial force are transferred across the rigid member (72).

13. The clutch of Claim 12, including means (90) for maintaining each pair of blocker surfaces (44a, 44b and 46a, 46b) in alignment with the circumferential space between the ends (74, 76) of each rigid member (72).

14. The clutch of claim 13, wherein:

each baulkring (40, 42) includes blocker teeth (44, 46) defining each pair blocker surfaces (44a, 44b and 46a, 46b) and extending axially between the circumferentially spaced apart ends (74, 76) of each rigid member (72) while the sleeve (34) is in the neutral position.

15. The clutch of claim 14, wherein:

the blocker teeth (44, 46) of each baulkring (40, 42) extending axially between the circumferentially spaced apart ends (74, 76) of at least one of the rigid members (72) including axially overlapping extensions (244c, 246c) for maintaining said alignment.

16. A clutch (18) for frictionally synchronizing and positive connecting first and second drives (12, 16) disposed for relative rotation about a common axis (12a); the clutch comprising:

first jaw means (36c) axially movable from a neutral position to an engaged position with second jaw means (30) for positive connecting the drives in response to engaging movement of the first jaw means (36c) by an axially directed shift force ( $F_o$ );

a first friction surface (50) axially movable into engagement with a second friction surface (26) in response to the engaging movement of the first jaw means (36c) for producing a synchronizing torque ( $T_o$ );

a hub (32) with a connecting means to the first jaw means (36c) for allowing axial movement of first jaw means (36c) with respect to the hub (32) and preventing rotational movement of first jaw means (36c) with respect to the hub (32);

a first baulkring (42) including the first friction surface (50) and a plurality of first blocker surfaces (46a), the baulkring being axially movable away from the hub (32) toward the second friction surface (26); characterized by:

the hub (32) including a first plurality of an-

gled hub surfaces (70b); and  
 a plurality of blocking elements (72) mounted for fixed axial movement with th first jaw means (36c) and limited rotational mov m nt relative to the first jaw means (36c) and th hub (32), the elements positioned to contact the angled hub surfaces (70b) and the baulkring (42) blocker surfaces (46a) for producing an additional axial force ( $F_a$ ) in the direction of the shift force ( $F_o$ ) due to reaction to the friction surface (50) torque transmitted through the baulkring (42) blocker surface (46a) thus producing increased axial force on the friction surface (50) and increased torque for synchronizing than is available from shift force ( $F_o$ ) alone.

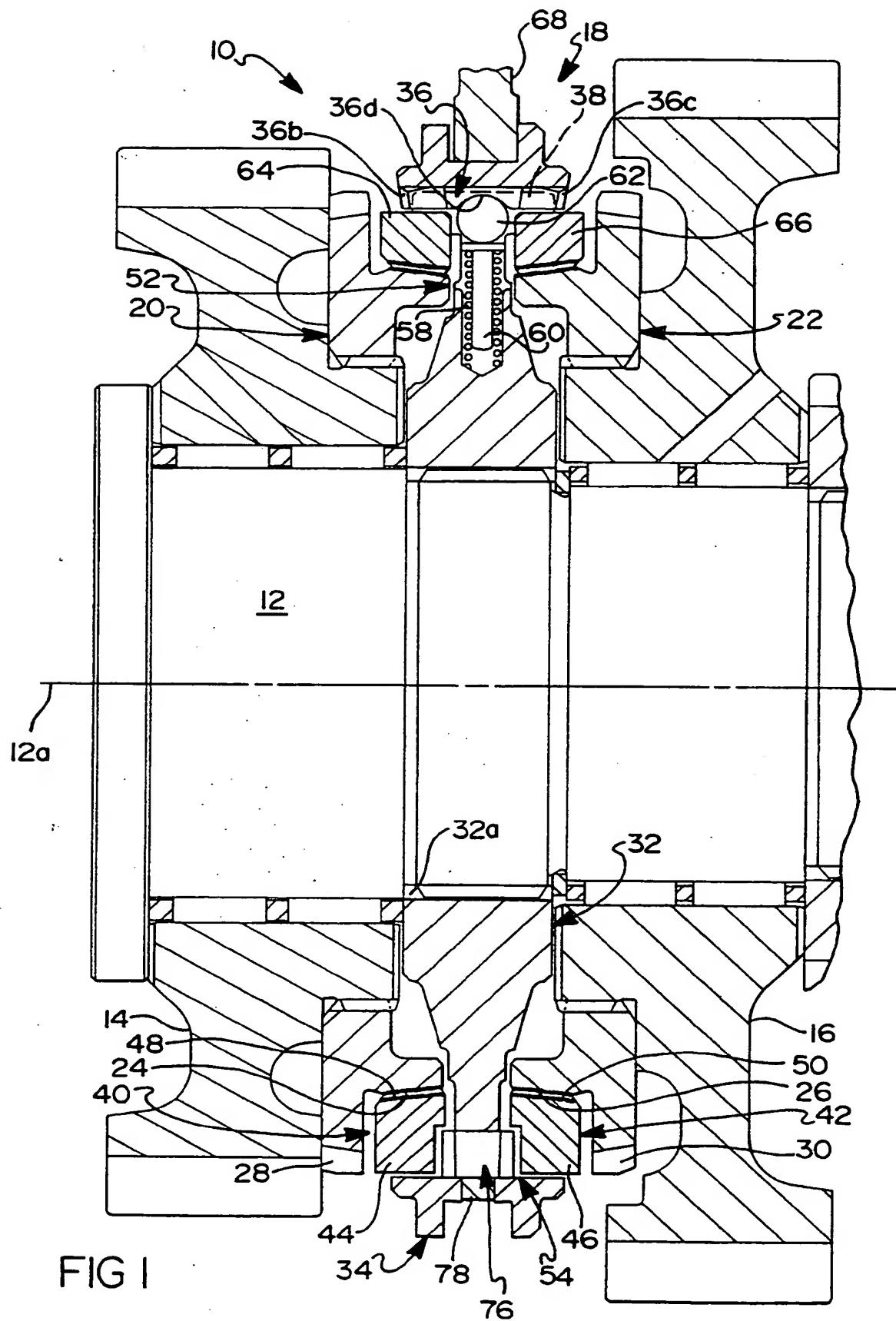
17. The clutch of claim 16, wherein the hub (32) and at least one of the blocking elements (74) each include a non-boost surface (70e,74c) extending perpendicular to a rotational plane of the hub and engaged when the first jaw means (36c) is in a neutral position.

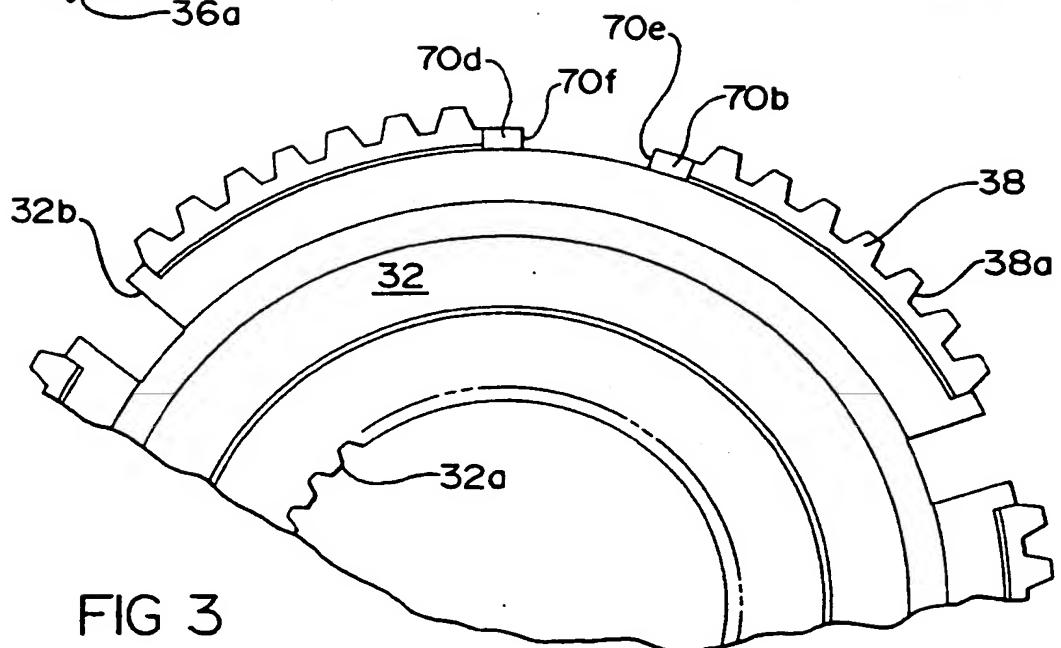
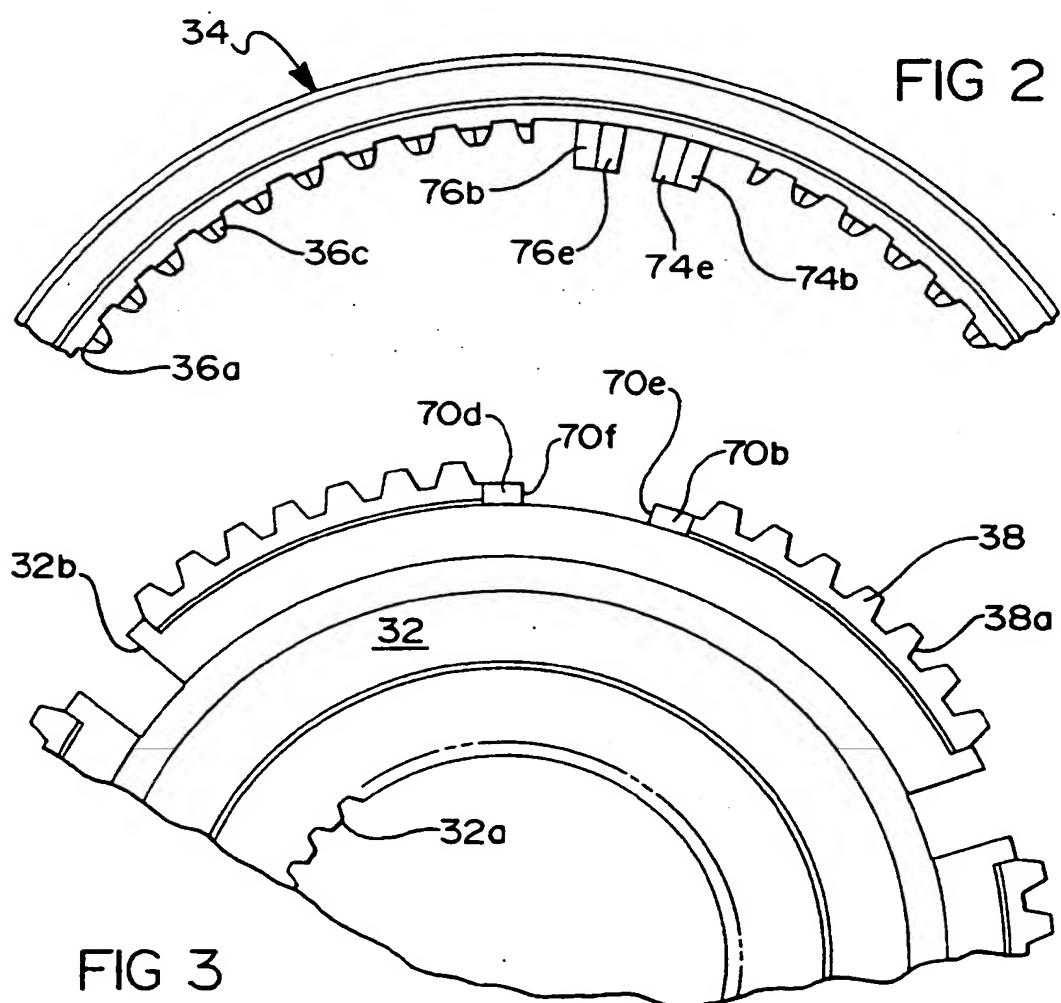
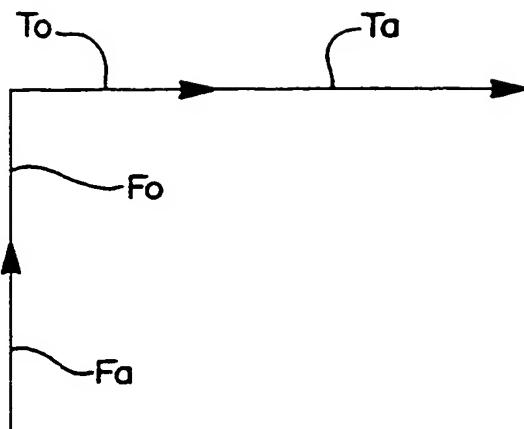
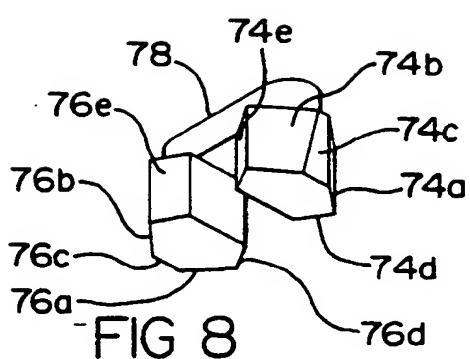
18. The clutch of claim 16, wherein the angled hub surfaces (70b) remain in contact with the elements (74) after the blocker surfaces (46a) move out of contact with the element for providing an assist force for moving the first jaw means (36c) into engagement with the second jaw means (30).

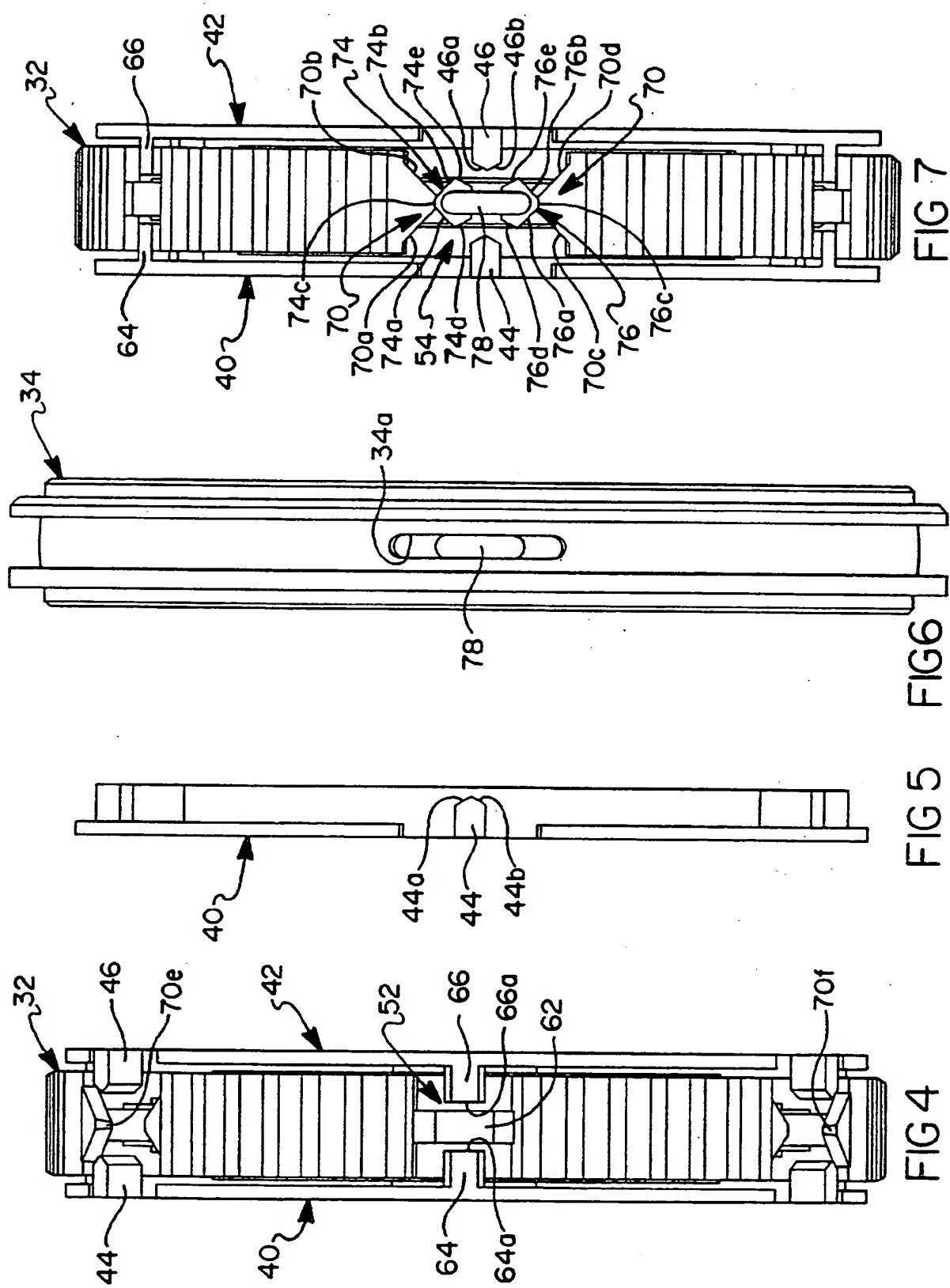
19. The clutch of claim 18, wherein the hub (32) and at least one of the blocking elements (74) each include a non-boost surface (70e,74c) extending perpendicular to a rotational plane of the hub and engaged when the first jaw means (36c) is in a neutral position.

20. The clutch of claim 16, further including a third drive (14) disposed for rotation about a common axis (12a) relative to the first and second drives (12,16) and axially spaced from the second drive (16);  
 a third jaw means (36b) axially movable from a neutral position into an engaged position with a fourth jaw means (28) for positive connecting the first and third drives (12,14) in response to engaging movement of the third jaw means (36b) by a second shift force ( $F_o$ ) directed axially opposite the first shift force ( $F_o$ );  
 a third friction surface (48) axially movable into engagement with a fourth friction surface (24) in response to engaging movement of the third jaw means (36b) for producing a synchronizing torque ( $T_o$ );  
 a second baulkring (40) including a third friction surface (48) and a plurality of second blocker surfac s (44a), the baulkring b eing axially movable away from the hub (32) toward a

fourth friction surfac (24);  
 the hub (32) including a plurality of second angled hub surfaces (70a); and  
 the elements positioned to contact the second angled hub surfaces (70a) and the sec-  
 ond baulkring blocker surfaces (44a) for produc-  
 ing an additional axial force ( $F_a$ ) in the direc-  
 tion of the second shift force due to reaction to the  
 friction surface (48) torque transmitted through  
 the second baulkring blocker surfaces (44a) thus  
 producing increased axial forces on the third fric-  
 tion surface (48) and increased torque for syn-  
 chronizing than is available from the second shift  
 force ( $F_o$ ) alone.







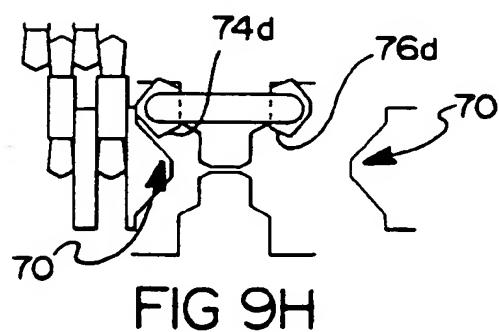
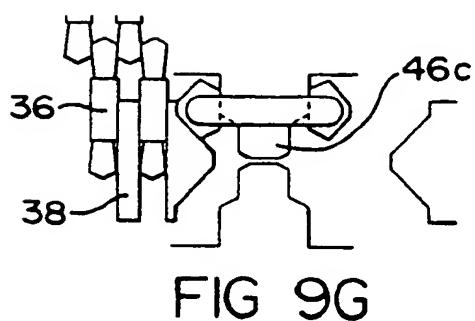
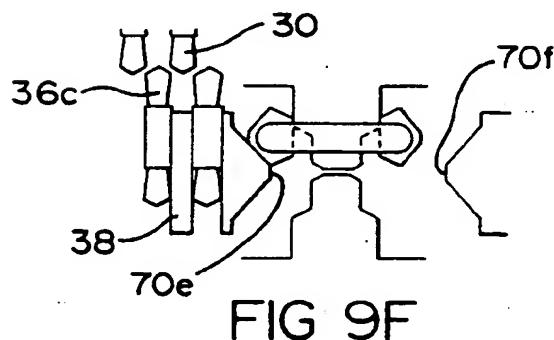
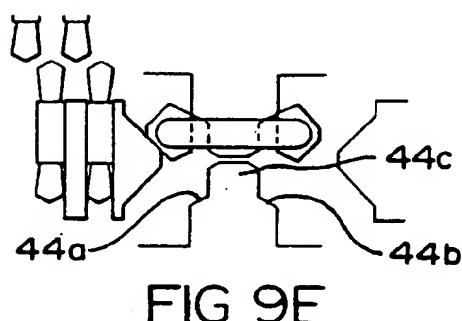
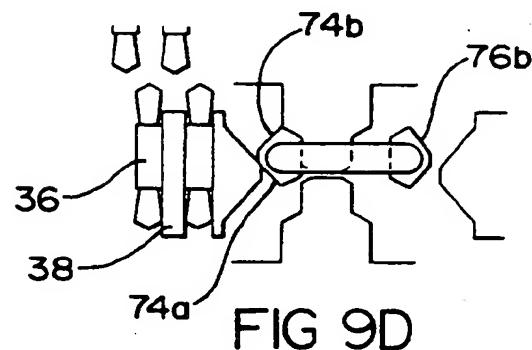
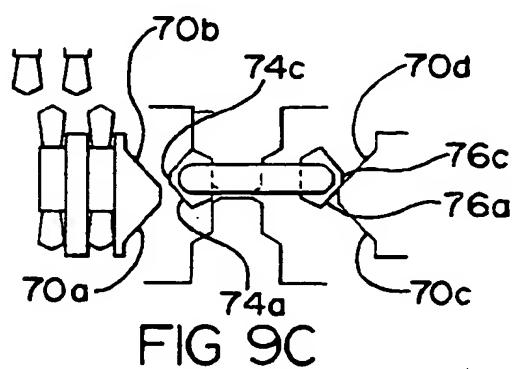
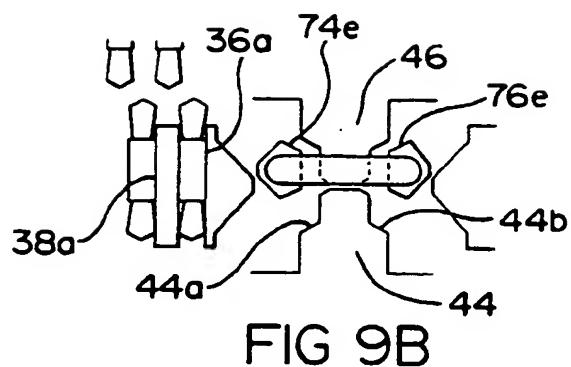
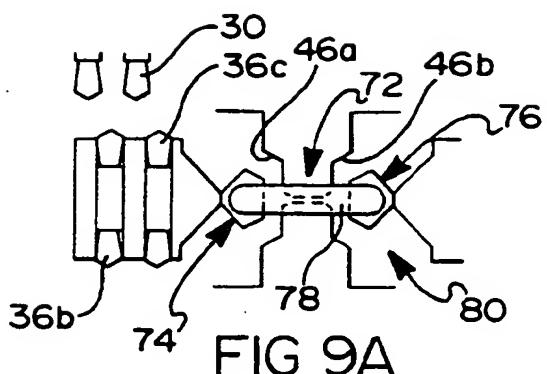


FIG 11

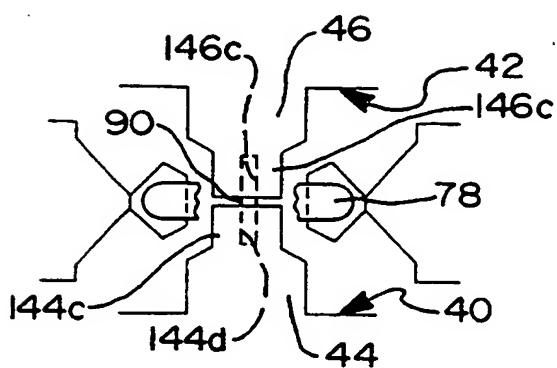


FIG 12

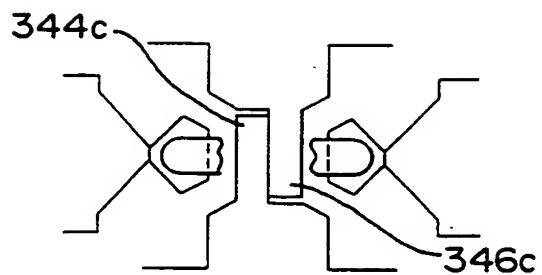
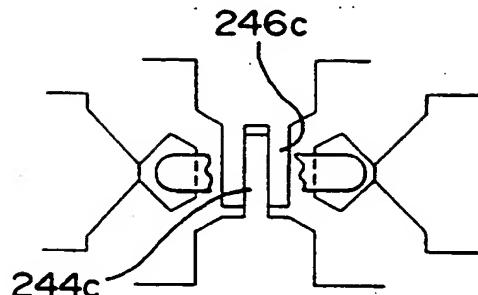


FIG 13A

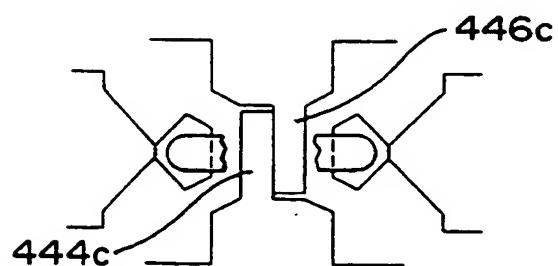


FIG 13B



European Patent  
Office

## EUROPEAN SEARCH REPORT

Application Number  
EP 94 30 9516

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.)
D, A	US-A-3 548 983 (HIRAIWA) * column 2, line 27 - column 7, line 53; figures 1-14 *	1, 12, 16	F16D23/06
A	GB-A-1 539 258 (ZF) * page 2, line 115 - page 3, line 44; figures 7-9 *	1, 12	
A	GB-A-427 363 (STANDARD MOTOR) * page 3, line 54 - page 4, line 43; figures 1-4 *	16	
The present search report has been drawn up for all claims			
Place of search	Date of completion of the search	Examiner	
THE HAGUE	7 April 1995	Baldwin, D	
CATEGORY OF CITED DOCUMENTS			
X : particularly relevant if taken alone	T : theory or principle underlying the invention		
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